Comment to the Board of Governors of the Federal Reserve System: Principles for Climate-Related Financial Risk Management for Large Financial Institutions

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This paper responds to a request for comment from the Board of Governors of the Federal Reserve System (hereinafter Fed) on its "high-level framework" "draft principles" for the evaluation and management of climate-related financial risks confronting Fed-supervised financial institutions with over $100 billion in total consolidated assets.[1] It is organized as follows:

* Senior fellow, American Enterprise Institute. The views expressed are solely those of the author.

[1] See https://www.govinfo.gov/content/pkg/FR-2022-12-08/pdf/2022-26648.pdf.

Summary

The draft principles published by the Fed for the evaluation by Fed-supervised financial institutions of climate-related physical and transition risks are fatally flawed, and should be withdrawn. The Fed assumes physical risks that are not consistent with the body of evidence on climate phenomena, and a prospective evolution of climate-related public policies that at most are highly unlikely to be implemented and in reality would prove virtually impossible to implement. Moreover, financial institutions, however large, are incapable of conducting the requisite analysis of future climate phenomena — even the Federal government cannot do so in a way that is consistent with the data — with respect to which the scientific uncertainties are vastly greater than commonly asserted. With respect to the transition (policy-related) risks noted by the Fed in its draft principles: The evaluation of such risks would require speculation about the evolution of political conditions and public policies that would be almost wholly speculative. Moreover, the overwhelming body of evidence suggests strongly that the "transition to a lower-carbon economy" would prove hugely expensive, so that the almost-explicit Fed assumption that such a "transition" is a virtual certainty is not to be taken seriously.

The range of alternative assumptions about central parameters is too great to yield clear implications for the climate "risks" facing specific financial institutions, economic sectors, and geographic regions. Those central parameters include the choices among climate models, the assumed sensitivity of the climate system to increases in the atmospheric concentration of greenhouse gases (GHG), ensuing conclusions about the relative contributions of natural and anthropogenic influences upon climate phenomena, the assumed future increase in atmospheric GHG concentrations through, say, 2100, and the analytic assumptions underlying calculations of the effects of aerosol emissions on cloud formation, about which surprisingly little is known. That short list is far from exhaustive.

If large financial institutions banks are driven to use the same (or similar) sets of assumptions about central parameters, a very real danger would arise of more-or-less homogeneous predictions inconsistent with historical, ongoing, and prospective climate phenomena. If they opt to use sets of assumptions that differ in important dimensions, the ensuing predictions about future climate phenomena ("risks") would vary substantially, yielding very large uncertainties in terms of the information made available to investors and regulators.

It is reasonable to hypothesize that financial institutions driven to evaluate climate "risks" will have powerful incentives to undertake climate analysis driven not by the actual evidence and the peer-reviewed literature on climate phenomena. Instead, they will be driven to undertake such analysis, whether in response to regulatory directives or to political pressures, under assumptions and methodologies insulating them from adverse regulatory actions, litigation threats, and political pressures.

It is reasonable to hypothesize also that the aggregate, sectoral, and geographic benefits (that is, positive "risks") of increasing atmospheric concentrations of greenhouse gases (GHG), as reported by the National Oceanic and Atmospheric Administration and in the peer-reviewed literature, will be excluded from such analytic efforts.

The proposed requirement for the analysis of "transition risks" assumes a "transition" away from fossil fuels that is very likely to border on the impossible as a matter of economic feasibility. In any event, any such analysis of "transition risk" must be based upon predictions of the future evolution of energy and other policies over decades, an exercise in political prognostication that no financial institution, however large — indeed that anyone — is in a position to undertake in a fashion that is not wholly speculative.

Because the perceived "climate "risks" confronting financial institutions are dependent upon crucial choices among alternative assumptions, the evaluation of such "risks" would be largely arbitrary given that the "correct" assumptions are very far from obvious. A misallocation of capital is a likely result, which means that a requirement that climate "risks" be evaluated would be likely to weaken the pursuit of the safety, soundness, and systemic stability objectives that are the formal mandates for the Fed.

When "risk" analysis becomes an arbitrary function of choices among assumptions complex, opaque, and far from obvious, the traditional safety, soundness, and systemic stability objectives that are the formal mandates for the Fed inexorably will be diluted and rendered far less useful for the investment and capital markets, an outcome diametrically at odds with the ostensible objectives of those advocating the evaluation of climate "risks." Moreover, the "risks" of anthropogenic climate change are far from the only such mass-geography "risks." A bias toward focusing only on climate "risks" would distort the allocation of capital.

The combination of very great climate uncertainties and litigation and regulatory threats will create a demand from the banking sector for detailed regulations on how to structure the analysis of climate risks. Because the uncertainties attendant upon the future effects of increasing atmospheric concentrations of GHG are so great, a top-down regulatory approach for the evaluation of any attendant "risks" is itself very risky. A wiser approach would entail allowing market forces to make such "risk" determinations in a bottom-up fashion, thus avoiding an obvious politicization of the allocation of capital.

A Fed mandate that large banks evaluate climate "risks" represents a blatant effort to distort the allocation of capital away from economic sectors disfavored by certain political interest groups pursuing ideological agendas. This would represent the return of Operation Choke Point, a past attempt to politicize access to capital, one deeply corrosive of our legal and constitutional institutions.

Protection of those institutions is consistent only with formal policymaking by the Congress through enactment of legislation, rather than with powerful pressures, whether formal or informal, exerted by regulatory agencies. This institutional protection would preserve the traditional roles of the private sector and of the government, respectively, as part of the larger permanent objectives of maximizing the productivity of resource use under free market competition, and of preserving the political accountability of the policymaking process under the institutions of democratic decisionmaking as constrained by the constitution.

I. No Financial Institution Is Capable of Conducting the Largely Speculative Risk Analyses Defined by the Fed

The draft principles under consideration by the Fed for climate-related financial risk management by large banks assume that the evaluation of such "risks" — that is, a disaggregation of overall climate phenomena affected by increasing atmospheric concentrations of greenhouse gases (GHG) by sector and by geographic region — would be straightforward. Instead, even at the global level, the uncertainties are staggering, in particular for the evaluation of climate phenomena decades or centuries in the future.[2] Disaggregation of such analysis by economic sector and geographic region would be fraught with uncertainties and a requirement for choices among alternative assumptions even greater. The proposed requirement that the Board of a financial institution demonstrate an understanding of climate-related financial risk exposures is preposterous in that bank officials are in no position to evaluate the enormous complexities of climate science, and also is curiously unhelpful in it is far from clear as to precisely what the relevant officials are supposed to understand. Moreover, the concept of systemic risk can be defined in a number of alternative ways, some of which conflict, and regulators have not demonstrated that they have mastered the task of analyzing the systemic risks engendered by a large and complex series of risks confronting individual financial institutions.[3]

The massive uncertainties and analytic difficulties inherent in any such assessments of "financial risks" created by changing climate phenomena will drive bank managements to outsource such risk analysis to outside consultants, the choices among whom will be driven not by any goal of analytic rigor, but instead by a heavy potential for regulatory and litigation penalties. Accordingly, only the most extreme scenarios will be viewed as relevant, a methodology that will distort the allocation of capital, and, perhaps ironically, will have the effect of weakening the financial performance of the banks forced into such analytic biases, and therefore of increasing the systemic risks, however defined, confronting the financial sector writ large. For the Fed, a regulatory framework that engenders such outcomes and with them a weaker U.S. economy in the aggregate is deeply inappropriate.

The combination of very great climate uncertainties and the litigation and regulatory threats will create a demand from the business sector for detailed regulations on how to structure the analysis of climate risks. Regulatory agencies are hardly better suited to conduct such analysis in an objective and neutral manner. Both large banks and government agencies will have powerful incentives to use the Environmental Protection Agency climate model, used by most Federal agencies to evaluate climate trends and the effects of climate policies; precisely because it is the U.S. government model, it would be difficult to attack a financial institution for choosing it.[4] For the earlier suite of climate models (CMIP-5), the EPA model provided predictions close to the average of those models under a given set of underlying assumptions, equilibrium climate sensitivity in particular. For the new suite (CMIP-6), the EPA model provides predictions cooler than the average of those models, not because the EPA model now is providing predictions more

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[2] See, e.g., Figure SPM.2 in "The Physical Science Basis" section of the most recent IPCC report, at https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf.

[3] See, e.g., https://www.newyorkFed.org/medialibrary/media/newsevents/events/research/2006/0518-background.pdf and https://www.researchgate.net/publication/279977936_The_Concept_of_Systemic_Risk.

[4] See www.magic.org.

consistent with the historical evidence, but because the CMIP-6 models have incorporated a range of climate sensitivity assumptions and estimates higher on average than those in the CMIP-5 iteration. That range of climate sensitivity values in CMIP-6 also is wider than that in CMIP-5, meaning that the uncertainty of the climate models is increasing. Note that the CMIP-5 and CMIP-6 models on average overstate the historical temperature record for the mid-troposphere by a factor of over 2.3.[5]

Furthermore, large low-probability risks are ubiquitous. Wars, terrorist acts, meteor strikes, mass volcanic eruptions, tsunamis, adverse weather events, and the like are only the beginning of a long list that does not require an overactive imagination to construct. For the Fed, a focus on only a small subset of such potential risks is arbitrary: Why some — or, indeed, only one — and not others? For large banks, a focus on that small subset as mandated by regulatory imperatives again creates a likelihood of a substantial misallocation of capital, weaker financial performance, and another ironic increase in systemic risks. And again for the Fed: A regulatory framework that engenders such outcomes and with them a weaker U.S. economy in the aggregate is deeply inappropriate.

The Fed should abandon this effort to force large banks to evaluate climate risks — to conduct highly complex and uncertain analyses that they are in no position to undertake — and return to a single minded focus on its traditional objectives of safety, soundness, and stability for the financial system.[6]

As noted above, the proposed requirement for the analysis of "transition risks" assumes a "transition" away from fossil fuels that is very likely to border on the impossible as a matter of economic feasibility. In any event, any such analysis of "transition risk" must be based upon predictions of the future evolution of energy and other policies over decades, an exercise in political prognostication that no financial institution, however large — indeed that anyone — is in a position to undertake in a fashion that is not wholly speculative.

II. Climate Uncertainties and Choices Among Crucial Assumptions

Notwithstanding ubiquitous assertions that climate science is "settled," that a crisis is upon us or looming large, and that government policies must address the "existential threat" posed by anthropogenic climate change, in reality the uncertainties attendant upon the prospective effects of increasing atmospheric concentrations of GHG are very substantial. Moreover, no evidence supports the "crisis" narrative, as discussed below. These realities are illustrated by the ranges of various estimates published by the Intergovernmental Panel on Climate Change (IPCC) in its most recent Assessment Report, by the wide range of temperature paths projected by the mainstream climate models, and by the scientific literature more generally.[7]

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[5] See https://clintel.org/new-presentation-by-john-christy-models-for-ar6-still-fail-to-reproduce-trends-in-tropical-troposphere/.

[6] See https://www.federalreserve.gov/aboutthefed.htm.

[7] See, e.g., Figure 2.5 in the IPCC Fifth Assessment Report (2013), on alternative paths for future temperature changes, at https://www.ipcc.ch/report/ar5/syr/synthesis-report/. On the wide range of temperature projections yielded by the mainstream climate models, see Figure 2 in the testimony of John R. Christy before the U.S. House Committee on Science, Space, and Technology, March 29, 2017, at https://science.house.gov/imo/media/doc/Christy%20Testimony_1.pdf?1. On the general state of scientific

The evaluation of climate "risks" to large banks would require choices among the available climate models, choices among alternative assumptions about the path of future atmospheric concentrations of GHG, choices among assumptions about the effect of increasing GHG concentrations upon the climate system, that is, the "sensitivity" of the climate system and thus the relative importance of natural and anthropogenic influences upon climate phenomena, and deeply problematic assumptions about the effects of aerosol emissions on cloud formation, about which little is known.[8] That list is very far from exhaustive.

Let us note that the mainstream climate models have found it very difficult to predict the historical and current climate record; as an example, the models have been unable to explain the warming observed from 1910-1945.[9] That period of warming cannot have been the result of increased atmospheric concentrations of GHG, in that such concentrations had increased only from about 278 ppm in 1750 to about 300 ppm by 1910, and 310 ppm by 1945.[10] Another example: Every climate model predicts that increasing atmospheric concentrations of GHG should result in an enhanced heating effect in the mid- and upper troposphere over the tropics. The satellites have been unable to find that effect, or in some analyses an effect close in magnitude to that predicted by the models.[11] In the latest iteration of the suite of climate models, to be applied in the next IPCC Assessment report, the average predicted tropospheric temperature increase for 1979-2019 is 0.40 degrees C per decade. The actual record as measured by the satellites: 0.16 degrees C per decade.[12] The climate models on average have overstated the temperature record by a factor of more than two.

Consider only the effect of varying assumptions about the future path of atmospheric GHG concentrations. IPCC in its 5th (2013) Assessment Report uses four such alternative paths:

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uncertainty in the context of climate phenomena, see e.g., Judith Curry, "Uncertainty About the Climate Uncertainty Monster," *Climate Etc.*, May 19, 2017, at https://judithcurry.com/2017/05/19/uncertainty-about-the-climate-uncertainty-monster/.

[8] See, e.g., Judith Curry, "The Cloud-Climate Conundrum," *Climate Etc.*, June 2, 2016, at https://judithcurry.com/2016/06/02/the-cloud-climate-conundrum/.

[9] See the HadCRUT5 reconstructions of temperature anomalies at https://crudata.uea.ac.uk/cru/data/temperature/. Interestingly enough, the Russian climate models from the Institute for Numerical Mathematics (models INM-CM4 and INM-CM4.8) do the best job of predicting the past and the present. See http://www.glisaclimate.org/node/2220 and https://www.researchgate.net/publication/329748540_Simulation_of_the_modern_climate_using_the_INM-CM48_climate_model.

[10] See the NOAA reconstruction of carbon dioxide emissions and concentrations for 1750-2019 at https://www.climate.gov/sites/default/files/CO2_emissions_vs_concentrations_1751-2019_lrg.gif.

[11] The tropics for the most part are water, and emissions of additional GHG would warm the earth slightly, resulting in an increase in ocean evaporation. In the climate models, as the water vapor rises into the mid troposphere, it condenses, releasing heat. This seems straightforward, but efforts to demonstrate this phenomenon with satellite measurements have proven very difficult. See Ross McKitrick and John R. Christy, "Pervasive Warming Bias in CMIP6 Tropospheric Layers," *Earth and Space Science*, Vol. 7, Issue 9 (September 2020), at https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020EA001281; and Ross McKitrick, "New Confirmation That Climate Models Overstate Atmospheric Warming," *Climate Etc.*, August 25, 2020, at https://judithcurry.com/2020/08/25/new-confirmation-that-climate-models-overstate-atmospheric-warming/.

[12] See the Coupled Model Intercomparison Project, Phase 6, at https://pcmdi.llnl.gov/CMIP6/. See also, e.g., the recent presentation by Professor John R. Christy at https://www.youtube.com/watch?v=D2Cd4MLUoN0.

Representative Concentrations Pathways 2.6, 4.5, 6, and 8.5.[13] The following table illustrates the range of temperature effects ("anomalies") by 2100 under the four RCPs.

Central Parameters of IPCC AR5 RCP Scenarios

	-------Representative Concentration Pathway------			
Year 2100	2.6	4.5	6	8.5
GHG concentration (ppm)	490	650	850	1370
Average increase 2018-2100 (ppm)	1.1	3.0	5.5	11.9
Temperature anomaly 2100 (°C)	1.5	2.4	3.0	4.9

Source: G.P. Wayne, "The Beginner's Guide to Representative Concentration Pathways," *Skeptical Science*, August 2013.
Note: RCP 2.6 (sometimes denoted RCP3PD) predicts radiative forcing of 3 Wm^2 before 2100, declining to 2.6 Wm^2 by 2100. "PD" stands for "peak and decline."

Neither the Fed nor other government agencies nor large banks are in a position to evaluate the strengths and weaknesses of alternative RCP assumptions, or of the other crucial parameters underlying climate projections in the context of GHG emissions.[14] The IPCC in the 2013 Assessment Report provides a range of estimates for the equilibrium sensitivity of the climate system, from 1.5 degrees to 4.5 degrees, with a mean of 3 degrees.[15] Many of the more extreme or "alarmist" assertions of the effects of anthropogenic climate change assume RCP8.5 and a climate sensitivity of 4.5 degrees (or even higher). The numerous estimates reported in the peer-reviewed literature do not support that assumption, instead supporting an assumption of 2 degrees or even

[13] The figures (2.6, etc.) are not temperature effects; they are theoretical calculations of "radiative forcings" in watts per square meter. For an introduction, see G.P. Wayne, "The Beginner's Guide to Representative Concentration Pathways," *Skeptical Science*, August 2013, at https://skepticalscience.com/docs/RCP_Guide.pdf. IPCC in the 6th Assessment Report switched to "Shared Socioeconomic Pathways" as scenarios, but they are deeply problematic as combinations of climate phenomena and economic assumptions. See Benjamin Zycher at https://www.aei.org/wp-content/uploads/2023/01/NCA5-Zycher-comment-Jan-2023.pdf, section VI.

[14] Note that RCP8.5 is a popular assumption among those advocating strong climate policies, but it is a scenario essentially impossible. Under RCP8.5, atmospheric concentrations of GHG rise at almost 12 parts per million (ppm) through 2100 as an annual average; the average for 1985-2019 was about 1.9 ppm, and the single largest increase was about 3 ppm in 2016. See the data reported by NOAA at https://www.esrl.noaa.gov/gmd/ccgg/trends/global.html. See Kevin Murphy, "Reassessing the RCPs," *Climate Etc.*, January 28, 2019, at https://judithcurry.com/2019/01/28/reassessing-the-rcps/; and Judith Curry, "Is RCP8.5 An Impossible Scenario?", *Climate Etc.*, November 24, 2018, at https://judithcurry.com/2018/11/24/is-rcp8-5-an-impossible-scenario/.

[15] The equilibrium sensitivity of the climate system is the temperature increase that would result from a doubling of atmospheric concentrations of GHG, after the climate system were to "finalize" all attendant adjustments.

less; the range estimated from the actual data is 1.5 to 2.3 degrees C.[16]

Again with respect to the enormous complexities inherent in the analysis of climate phenomena and "risks": Neither the Fed nor other government agencies nor large banks are in a position to evaluate them in ways that would yield useful information for investors or regulators. Even government agencies and international bodies wholly dedicated to such analyses find the task daunting. Instead, large banks will be driven to adopt assumptions — actually, to retain consultants who will do so — minimizing the degree to which their analyses might subject them to political attacks, adverse regulatory actions, and litigation. This is very different from an objective effort to evaluate climate phenomena and a reasonable range of prospective effects of increasing GHG concentrations, that is, climate "risks."

The combination of very great climate uncertainties and the litigation and regulatory threats will create a demand from the business sector for detailed regulations on how to structure the analysis of climate risks. Regulatory agencies are hardly better suited to conduct such analysis in an objective and neutral manner. Both large banks and government agencies will have powerful incentives to use the Environmental Protection Agency climate model, used by most Federal agencies to evaluate climate trends and the effects of climate policies; precisely because it is the U.S. government model, it would be difficult to attack a financial institution for choosing it.[17] For the earlier suite of climate models (CMIP-5), the EPA model provided predictions close to the average of those models under a given set of underlying assumptions, equilibrium climate sensitivity in particular. For the new suite (CMIP-6), the EPA model provides predictions cooler than the average of those models, not because the EPA model now is providing predictions more consistent with the historical evidence, but because the CMIP-6 models have incorporated a range of climate sensitivity assumptions and estimates higher on average than those in the CMIP-5 iteration. That range of climate sensitivity values in CMIP-6 also is wider than that in CMIP-5, meaning that the uncertainty of the climate models is increasing.[18]

Again, large banks conducting climate "risk" analysis will have powerful incentives to choose among assumptions on future emissions and atmospheric concentrations, climate sensitivity, and other crucial parameters so as to insulate themselves from political attack, adverse regulatory actions, and litigation. They thus will be led toward analytic homogeneity, yielding a very real danger of an artificial "consensus" regardless of the actual evidence, and perhaps largely inconsistent with it. Any such consensus would be an artifact of the political pressures to which the large banks would be subjected; it would have nothing to do with "science."

If, implausibly, those conducting climate "risk" analysis were to opt to use models and/or sets of assumptions that differ in important dimensions, the ensuing predictions about future climate phenomena ("risks") would vary substantially or hugely, yielding very large uncertainties

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[16] See Patrick J. Michaels and Paul C. Knappenberger, *Lukewarming: The New Climate Science That Changes Everything*, Washington D.C.: Cato Institute, 2016; and the recent presentation by Professor John R. Christy at https://www.youtube.com/watch?v=D2Cd4MLUoN0.

[17] This is the Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC), at www.magic.org. The summary analysis presented below uses version 5.3. Version 6.0 is available, but generates predictions only on the temperature effects of various GHG concentration scenarios.

[18] Private communication with Professor John R. Christy, March 14, 2021. See CMIP-5 at https://pcmdi.llnl.gov/mips/cmip5/; and CMIP-6 at https://pcmdi.llnl.gov/CMIP6/.

in terms of "risk" implications. What would the Fed do under that condition, how would large banks respond, and — again — what would such decisions have to do with "science"?

Those political pressures will lead large banks and government agencies not to consider the benefits of increasing atmospheric concentrations of GHG, as reported by the National Oceanic and Atmospheric Administration (NOAA), and in the peer-reviewed literature. Examples are planetary greening, increased agricultural productivity, increased water use efficiency by plants, and reduced mortality from cold.[19] Nor will such analysis include important dimensions of the adverse impacts of government climate policies, which as a core imperative must have the effect of increasing energy costs artificially, notwithstanding common assertions that alternative energy sources are competitive in terms of costs.[20] In short, government policies that force or induce large banks to evaluate the climate "risks" confronting their operations and markets will yield confusion rather than material information. One result of such confusion would be important distortions in capital markets due to a weighting of climate "risks" above those posed by other important phenomena, whether natural or manmade.

III. The Fed's Physical Risk Assertions Are Inconsistent With the Evidence on Climate Phenomena

The Fed in the proposed principles defines the physical risks of climate change as follows:

> Physical risks refer to the harm to people and property arising from acute, climate-related events, such as hurricanes, wildfires, floods, and heatwaves, and chronic shifts in climate, including higher average temperatures, changes in precipitation patterns, sea level rise, and ocean acidification.[21]

This definition is justified by reference to the Financial Stability Oversight Council:

> The Financial Stability Oversight Council has described the impacts of physical risks as follows: 'The intensity and frequency of extreme weather and climate-related disaster events are increasing and already imposing substantial economic costs. Such costs to the economy are expected to increase further as the cumulative impacts of past and ongoing global emissions continue to drive rising global temperatures and related climate changes, leading to increased climate-related risks to the financial system.'[22]

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[19] On the carbon dioxide "greening" effect see NOAA at https://www.nasa.gov/feature/goddard/2016/carbon-dioxide-fertilization-greening-earth; and Zaichun Zhu, *et. al.*, "Greening of the Earth and Its Drivers," *Nature Climate Change*, Vol. 6 (2016), pp. 791-795, at https://www.nature.com/articles/nclimate3004. On the agricultural productivity effects, see, e.g., Goudriaan and Unsworth at https://acsess.onlinelibrary.wiley.com/doi/abs/10.2134/asaspecpub53.c8. On water use efficiency by plants, see, e.g., http://www.co2science.org/subject/w/summaries/wateruse.php. On the beneficial impacts of moderate warming on mortality, see https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(14)62114-0/fulltext.

[20] See Benjamin Zycher, *The Green New Deal: Economics and Policy Analytics*, American Enterprise Institute, 2019, at http://www.aei.org/wp-content/uploads/2019/04/RPT-The-Green-New-Deal-5.5x8.5-FINAL.pdf?x91208.

[21] See the proposed principles at p. 75267.

[22] *Ibid.* at fn. 2.

The available body of evidence does not support this series of assertions referenced by the Fed in support of its proposed principles. Anthropogenic climate change is "real" — increasing GHG concentrations are having detectable effects — and incontrovertible, but that does not tell us the magnitude of the observable impacts, which must be measured empirically. Temperatures are rising, but as the Little Ice Age ended no later than 1850, it is not easy to separate natural from anthropogenic effects on temperatures and other climate phenomena.[23] Also as noted above, the latest research in the peer-reviewed literature suggests that mankind is responsible for about half of the approximate temperature increase of 1.1 degrees C since 1880. Note that the surface temperature reconstructions from the National Oceanographic and Atmospheric Administration and from the Climate Research Unit at East Anglia University show a sharp temperature increase from 1910-1945, which cannot have been anthropogenic in origin.[24]

There is little trend in the number of "hot" days for 1895–2017; eleven of the 12 years with the highest number of such days occurred before 1960.[25] NOAA has maintained since 2005 the U.S. Climate Reference Network, comprising 114 meticulously maintained temperature stations spaced more or less uniformly across the lower 48 states, 21 stations in Alaska, and two stations in Hawaii.[26] They are placed to avoid heat island effects and other such distortions as much as possible; the reported data show no trend over the available 2005–20 reporting period.[27] A NOAA reconstruction of global temperatures over the past one million years, using data from ice sheet formations, shows that there is nothing unusual about the current warm period.[28]

Global mean sea level has been increasing at about 3.3 mm per year since satellite

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[23] On the Little Ice Age, see Michael E. Mann, "Little Ice Age," in *Encyclopedia of Global Environmental Change, Volume 1: The Earth System: Physical and Chemical Dimensions of Global Environmental Change*, ed. Michael C. MacCracken, John S. Perry and Ted Munn (Chichester, England: John Wiley & Sons, 2002), http://www.meteo.psu.edu/holocene/public_html/shared/articles/littleiceage.pdf.

[24] Respectively, see https://www.climate.gov/maps-data/dataset/global-temperature-anomalies-graphing-tool and https://crudata.uea.ac.uk/cru/data/temperature/. See also Benjamin Zycher at https://www.aei.org/wp-content/uploads/2023/01/NCA5-Zycher-comment-Jan-2023.pdf, pp. 3-5.

[25] For the reconstruction of the NASA data, see John R. Christy, "Average per Station (1114 USHCN Stations) 1895–2017: Number of Days Daily Maximum Temperature Above 100˚F and 105˚F," drroyspencer.com, http://www.drroyspencer.com/wp-content/uploads/US-extreme-high-temperatures-1895-2017.jpg.

[26] For the Climate Reference Network program description, see National Centers for Environmental Information, "U.S. Climate Reference Network," https://www.ncdc.noaa.gov/crn/.

[27] For a visualization of a prototypical station, see Willis Eschenbach, "NOAA's USCRN Revisited—No Significant Warming in the USA in 12 Years," Watts Up with That?, November 8, 2017, https://wattsupwiththat.com/2017/11/08/the-uscrn-revisited/. For the monthly data and charts reported by the National Oceanic and Atmospheric Administration (NOAA), see National Oceanic and Atmospheric Administration, "National Temperature Index," https://www.ncdc.noaa.gov/temp-and-precip/national-temperature-index/time-series?datasets%5B%5D=uscrn&parameter=anom-tavg&time_scale=p12&begyear=2005&endyear=2020&month=8.

[28] See R. Bintanja and R. S. W. van de Wal, "North American Ice-Sheet Dynamics and the Onset of 100,000-Year Glacial Cycles," *Nature* 454, no. 7206 (August 14, 2008): 869–72, https://www.researchgate.net/publication/23171740_Bintanja_R_van_de_Wal_R_S_W_North_American_ice-sheet_dynamics_and_the_onset_of_100000-year_glacial_cycles_Nature_454_869-872. NOAA published the underlying data at R. Bintanja and R. S. W. van de Wal, "Global 3Ma Temperature, Sea Level, and Ice Volume Reconstructions," National Oceanic and Atmospheric Administration, August 14, 2008, https://www.ncdc.noaa.gov/paleo-search/study/11933. For a chart showing the temperature record over one million years, see Institute for Energy Research, "Temperature Fluctuations over the Past Million Years," https://www.instituteforenergyresearch.org/wp-content/uploads/2020/03/temperature-flucturations.png.

measurements began in 1992. The tidal-gauge data before then show annual increases of about 1.9 mm per year, but that comparison does not show an acceleration in sea-level rise because the two datasets are not comparable. The tidal gauges do not measure sea levels *per se*; they measure the difference between sea levels and "fixed" points on land that in reality might not be fixed due to seismic activity, tectonic shifts, land settlement, etc. Accordingly, the data are unclear as to whether there is occurring an acceleration in sea level rise; it is reasonable to assume that there has been such an acceleration simply because temperatures are rising due to both natural and anthropogenic influences, as noted above, and such increases should result in more melting ice and the thermal expansion of water. But because rising temperatures are the result of both natural and anthropogenic causes, we do not know the relative contributions of those causes to any such acceleration.[29]

The Northern and Southern Hemisphere sea ice changes tell different stories; the arctic sea ice has been declining, while the Antarctic sea ice has been stable or growing.[30] U.S. tornado activity shows either no trend or a downward trend since 1954.[31] Tropical storms, hurricanes, and accumulated cyclone energy show little trend since satellite measurements began in the early 1970s.[32] The number of U.S. wildfires shows no trend since 1985, and global acreage burned has

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[29] See Frederikse *et. al.* at https://www.nature.com/articles/s41586-020-2591-3. As a crude approximation, the data suggest that about two-thirds of such sea level increases are due to ice melt, and one-third to thermal expansion of water. See Judith Curry, "Sea Level and Climate Change," Climate Forecast Applications Network, November 25, 2018, https://curryja.files.wordpress.com/2018/11/special-report-sea-level-rise3.pdf. Curry cites research from Xianyao Chen and colleagues, the central finding of which is that "global mean sea level rise increased from 2.2 ± 0.3 mm/year in 1993 to 3.3 ± 0.3 mm/year in 2014." See Xianyao Chen et al., "The Increasing Rate of Global Mean Sea-Level Rise During 1993–2014," *Nature Climate Change* 7 (June 26, 2017): 492–95, https://www.nature.com/articles/nclimate3325. Whether the trend from a 21-year period can yield important inferences is a topic not to be addressed here. For a different empirical conclusion from the tidal gauge record, see J. R. Houston and R. G. Green, "Sea-Level Acceleration Based on U.S. Tide Gauges and Extensions of Previous Global-Gauge Analyses," *Journal of Coastal Research* 27, no. 3 (May 2011): 409–17, https://meridian.allenpress.com/jcr/article-abstract/27/3/409/28456/Sea-Level-Acceleration-Based-on-U-S-Tide-Gauges?redirectedFrom=fulltext. For an example of temporary rapid sea-level rise in the 18th century, see W. R. Gehrels et al., "A Preindustrial Sea-Level Rise Hotspot Along the Atlantic Coast of North America," *Geophysical Research Letters* 47 (2020), https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2019GL085814. For further reported evidence of an acceleration, see Hans-Otto Pörtner et al., *Special Report on the Ocean and Cryosphere in a Changing Climate*, Intergovernmental Panel on Climate Change, 2019, https://www.ipcc.ch/srocc/.

[30] See https://www.thegwpf.org/content/uploads/2021/12/Bates-Sea-Ice-Trends.pdf?mc_cid=dac7df538b&mc_eid=ad653edd6d; and https://www.thegwpf.org/content/uploads/2022/04/Humlum-State-of-Climate-2021-.pdf?mc_cid=dac7df538b&mc_eid=ad653edd6d. See also Patrick J. Michaels, "Spinning Global Sea Ice," Cato Institute, February 12, 2015, https://www.cato.org/blog/spinning-global-sea-ice. It appears to be the case that the Antarctic eastern ice sheet — about two-thirds of the continent — is growing, while the western ice sheet (and the peninsula) may be shrinking. No agreed explanation for this phenomenon is reported in the literature.

[31] For the historical data reported by the NOAA, see National Ocean and Atmospheric Administration, "Historical Records and Trends," https://www.ncdc.noaa.gov/climate-information/extreme-events/us-tornado-climatology/trends.

[32] For data on global tropical cyclone activity, see Ryan N. Maue, "Global Tropical Cyclone Activity, updated March 16, 2021, at http://climatlas.com/tropical/.

declined over past decades.[33] The Palmer Drought Severity index shows no trend since 1895.[34] "Meteorological droughts do not show any substantial changes at the global scale in at least the last 120 years."[35] Neither global nor U.S. flooding over the past century is correlated with increasing GHG concentrations.[36] The available data do not support the ubiquitous assertions about the dire impacts of declining pH levels in the oceans.[37] The IPCC itself in the *Fifth Assessment Report* was deeply dubious about the various severe effects often asserted to be looming as impacts of anthropogenic warming, and the IPCC analysis in the *Sixth Assessment Report* is almost identical.[38]

The available body of evidence simply does not support the ubiquitous assertions that a climate "crisis" is upon us or looming large, or that "The intensity and frequency of extreme weather and climate-related disaster events are increasing and already imposing substantial economic costs." This means that the asserted climate "risks" threatening the operations, safety and soundness of large banks, and the stability of the financial system as a whole, are far less obvious than often assumed.

IV. The Fed Assumes a "Transition To a Lower-Carbon Economy" That Is Virtually Impossible Economically

The Fed defines "transition risk" as:

> Transition risks refer to stresses to certain institutions or sectors arising from the shifts in policy, consumer and business sentiment, or technologies associated with the changes that would be part of a transition to a lower

[33] For the reported U.S. wildfire data, see the EPA at https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires and the National Interagency Fire Center, "Total Wildland Fires and Acres (1926–2019)," https://www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html. On the decline in global area burned over past decades, see NASA at https://earthobservatory.nasa.gov/images/90493/researchers-detect-a-global-drop-in-fires; and Stefan H. Doerr and Cristina Santin, "Global Trends in Wildfire and Its Impacts: Perceptions Versus Realities in a Changing World," *Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences* 371, no. 1696 (2016), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4874420/pdf/rstb20150345.pdf.

[34] See US Environmental Protection Agency, "Climate Change Indicators: Drought," https://www.epa.gov/climate-indicators/climate-change-indicators-drought; and US Department of Commerce, National Climatic Data Center, "Divisional Data Select," https://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp.

[35] See Sergio M. Vicente-Serrano, *et. al.*, "Global Drought Trends and Future Projections," *Philosophical Transactions of the Royal Society*, October 2022, at https://www.researchgate.net/publication/364672519_Global_drought_trends_and_future_projections.

[36] On global flooding, see Glenn A. Hodgkins *et. al.* at https://www.sciencedirect.com/science/article/abs/pii/S002216941730478X#%21. On U.S. flooding see R. M. Hirsch and K. R. Ryberg, "Has the Magnitude of Floods Across the USA Changed with Global CO_2 Levels?," *Hydrological Sciences Journal* 57, no. 1 (2012): 1–9, at https://www.tandfonline.com/doi/full/10.1080/02626667.2011.621895?scroll=top&needAccess=true&.

[37] See CO_2 Science, "Ocean Acidification Database," http://www.co2science.org/data/acidification/results.php. See also Alan Longhurst, *Doubt and Certainty in Climate Science*, pp. 214–25, https://curryja.files.wordpress.com/2015/09/longhurst-print.pdf.

[38] Julie M. Arblaster et al., "Long-Term Climate Change: Projections, Commitments and Irreversibility—Final Draft Underlying Scientific-Technical Assessment," in *Working Group I Contribution to the IPCC Fifth Assessment Report (AR5), Climate Change 2013: The Physical Science Basis*, September 23–26, 2013, p. 12–78, http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_Chapter12.pdf. See also the AR6 at p. 12-115 at https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf.

carbon economy.[39]

The Fed again relies upon the Financial Stability Oversight Council:

> The Financial Stability Oversight Council has described the impacts of transition risks as: '. . . [Changing] public policy, adoption of new technologies, and shifting consumer and investor preferences have the potential to impact the allocation of capital . . . . If these changes occur in a disorderly way owing to substantial delays in action or abrupt changes in policy, their impact on firms, market participants, individuals, and communities is likely to be more sudden and disruptive.'[40]

That the Fed is relying on the assumption of a "potential to impact the allocation of capital" does not bode well for the evaluation of transition risks, in that there obviously exists a "potential" for a large number of alternative prospective outcomes. In particular, the assumed "transition to a lower carbon economy" is far less likely in prospect than the Fed is assuming casually, in that there is no actual evidence that "lower carbon" technologies are competitive now or prospectively without massive subsidies and other subventions. Consider for example the following data in Table 1 on the levelized costs of electric power produced with alternative technologies, as reported by the Energy Information Administration in its annual reports.[41] The table reports the data for 2010, 2016, and 2021, but the data are available annually.

Because the EIA estimates do not include important costs in the levelized cost estimates, the actual cost disadvantages of renewable power generation are substantially greater than those shown in the table below. Zycher reports an estimate of about $500 billion per year for an electricity grid comprising "decarbonized" technologies.[42] Holtz-Eakin et. al. report a similar cost estimate using a somewhat different methodology.[43] Turner and Lassman report an estimate of annual per-household cost of approximately $50,000 for full implementation of all net-zero

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[39] See the proposed principles at p. 75267.
[40] See the proposed principles at fn. 3.
[41] For 2010 through 2022, respectively: https://www.eia.gov/outlooks/archive/aeo10/electricity_generation.html, https://www.eia.gov/outlooks/archive/aeo11/electricity_generation.php, https://www.eia.gov/outlooks/archive/aeo12/electricity_generation.php, https://www.eia.gov/outlooks/archive/aeo13/electricity_generation.php, https://www.eia.gov/outlooks/archive/aeo14/electricity_generation.php, https://www.eia.gov/outlooks/archive/aeo15/pdf/electricity_generation_2015.pdf, https://www.eia.gov/outlooks/archive/aeo16/pdf/electricity_generation_2016.pdf, https://www.eia.gov/outlooks/archive/aeo17/pdf/electricity_generation.pdf, https://www.eia.gov/outlooks/archive/aeo18/pdf/electricity_generation.pdf, https://www.eia.gov/outlooks/archive/aeo19/pdf/electricity_generation.pdf, https://www.eia.gov/outlooks/archive/aeo20/pdf/electricity_generation.pdf, https://www.eia.gov/outlooks/archive/aeo21/pdf/electricity_generation.pdf, and https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf. The deflator applied to these data is the Producer Price Index for Electricity Generation: Utilities, as reported by the Federal Reserve Bank of St. Louis in the FRED database, at https://fred.stlouisfed.org/series/PCU2211102211104#0.
[42] See Benjamin Zycher, *The Green New Deal* at https://www.aei.org/wp-content/uploads/2019/04/RPT-The-Green-New-Deal-5.5x8.5-FINAL.pdf.
[43] See https://www.americanactionforum.org/research/the-green-new-deal-scope-scale-and-implications/.

programs including electric power, transportation systems, building retrofitting, etc.[44]

The cost experience in regions that have implemented energy "transition" policies does not bode well for the bland "transition" assumption on the part of the Fed.[45] The cost and performance disadvantages of electric vehicles, not of direct interest here, are equally stark.[46] In short, the Fed assumption that "a transition to a lower carbon economy" is a given, whatever the assumed time frame, is inconsistent with ongoing experience and with the latest cost data. It is not to be taken seriously.

Table 1
Levelized Costs of New Generation Resources
(year 2021 dollars per Mwh)

	----------Year----------		
Technology	2010	2016	2021
Coal	132.78	134.57	163.44
Gas Combined Cycle	99.86	74.33	39.94
Nuclear	144.08	131.52	88.24
Hydroelectric	144.08	86.74	170.39
Onshore Wind Incl Backup	327.81	203.68	158.09
Solar Photovoltaic Incl Backup	624.37	229.53	NA
Solar Standalone Incl Backup	NA	NA	154.35
Battery Storage	NA	NA	128.55

NA: not available.
Source: Author computations; see fn. 41.

V. Further Observations on the Concept of "Climate Risk"

It is clear that those in support of the proposition that large banks evaluate the "risks" of anthropogenic climate change to their operations view such analyses as "material" in terms of disclosures to regulators and investors.[47] Several problems are attendant upon that premise, in substantial part for the reasons discussed above. Any such projections of climate phenomena and resulting "risks" — far into the future — are very far from trivial methodologically. Which climate model(s) should banks use? Which assumptions about future emissions, about the sensitivity of the climate system, about policies to be adopted internationally, about the climate effects of those policies, *ad infinitum*, should large banks incorporate into those models? What confidence should

[44] See https://cei.org/studies/what-the-green-new-deal-could-cost-a-typical-household/.
[45] See, e.g., https://www.thegwpf.org/content/uploads/2022/08/EU-Climate-Policy-Failure.pdf; https://www.city-journal.org/californias-green-debacle; https://www.forbes.com/sites/adammillsap/2022/05/12/californias-energy-policy-shows-us-what-not-to-do/?sh=44947ab5634a; and Benjamin Zycher, *op. cit.*, fn. 42 *supra*.
[46] See Benjamin Zycher at https://www.aei.org/wp-content/uploads/2022/11/Zycher-Declaration-Ohio-CA-waiver-Oct-2022.pdf and at https://www.nationalreview.com/2021/03/the-electric-vehicle-campaign-comes-to-minnesota/.
[47] See a legal summary of the SEC disclosure requirements for public companies for material information at http://www.legalandcompliance.com/securities-resources/sec-requirements-for-public-companies/.

be attached to the predictions made by the models? Are those banks — even very large ones — in a position to do such analysis in a credible fashion? If not, whom should they retain to do that analysis for them, and how should they evaluate the differences among the available alternative providers of such analyses?

Note that the concept of "risk" by its very nature implies a range of possible outcomes delineated by a statistical distribution of likelihoods around some mean and with some standard deviation. "Uncertainty" clearly is a more accurate term than "risk" in this context, in that the mean and/or standard deviation of the relevant statistical distributions are very unlikely to be known. The reality is that a "climate risk" disclosure requirement would be deeply speculative, and the level of detail and the scientific sophistication that would be needed to satisfy such a requirement are staggering. Such "disclosures" and supporting analysis and documentation would take up thousands of pages, with references to thousands more, and the premise that this "disclosure" requirement would facilitate improved decisionmaking by bank managements and regulators is difficult to take seriously.

If climate "risks" are deemed important in terms of safety, soundness, and systemic stability objectives, why not others that also are uncertain or speculative? Climate "risks" are hardly the only ones potentially relevant to financial institutions, and all are difficult to evaluate and to incorporate into capital allocation decisions. What about massive volcanic eruptions? Asteroid impacts? Powerful earthquakes? Tsunamis? The potential problem of mass contagion is one with which we are far more familiar now than was the case only somewhat more than a year ago. The use of bioweaponry by terrorists, nuclear war, gamma ray storms, and on and on. Is climate "risk" the most important? If that is the hypothesis, what is the basis for it? Why are those others, and many more, not worthy of incorporation into disclosure requirements for large banks? What distortions would result from attention only to climate change and not others?

Because the perceived "climate "risks" confronting large banks are dependent upon crucial choices among alternative assumptions, the evaluation of such "risks" would be largely arbitrary given that the "correct" assumptions are very far from obvious. This means that a requirement, whether formal or informal, that climate "risks" be evaluated by large banks would weaken the overall management of risks by financial institutions. When "risk" analysis becomes an arbitrary function of choices among assumptions complex, opaque, and far from obvious, the traditional pursuit of safety and soundness inexorably will be hindered and rendered far less effective in terms of the investment and productivity objectives of the financial markets, an outcome diametrically at odds with the ostensible objectives of those advocating the evaluation of climate "risks."

For these reasons, the preliminary principles published by the Fed are deeply problematic. The principles simply shunt aside the massive analytic problems inherent in the analysis of climate "risks," instead emphasizing a general stance that market forces will not yield appropriate safety, soundness, and systemic stability outcomes attendant upon competitive market process in the absence of regulatory mandates. It is perhaps unsurprising that regulators view market incentives as insufficient to engender an efficient outcome in terms of resource allocation, and that a regulatory strengthening of such incentives automatically would yield an allocational improvement. That stance is very far from obviously correct.

VI. The Proposed Principles Are Corrosive of Our Constitutional Institutions

A mandate from the Fed that large banks evaluate climate "risks" is likely to distort the allocation of capital away from economic sectors disfavored by certain political interest groups pursuing ideological agendas. This would represent the return of Operation Choke Point, an attempt to politicize access to credit, one far broader than was applicable only to financial institutions, and deeply corrosive of our legal and constitutional institutions. Protection of those institutions is consistent only with formal policymaking by the Congress through enactment of legislation, rather than with pressures exerted by the Fed and other regulatory agencies.

Congress has enacted no statute requiring direct reductions in GHG emissions and no statute defining changes in climate phenomena as a threat to the soundness and stability of the financial system. The various subsidy programs and other such policies may or may not be based upon assumptions about the effects of those policies on future GHG emissions, but no such actual constraints have been enacted. Under the constitutional institutions governing U.S. statutory law and attendant policymaking, national "commitments" must be enacted by the Congress; executive orders do not carry the force of law, and as a formal matter it is not clear that they are binding even on executive-branch agencies.[48] The 2009 regulatory finding[49] by the EPA that "six greenhouse gases taken in combination endanger both the public health and the public welfare of current and future generations" is not derived from any law; it is instead a Supreme Court decision that led to it.[50] Because the endangerment finding is regulatory rather than statutory, it can be reversed by a new rulemaking, and the same is true for the "principles" now being considered by the Fed.

VII. Conclusions

The available analysis suggests that the prospective risks to financial institutions attendant upon anthropogenic climate change, at least in the aggregate, are much smaller than many assert. Consider the predictions from the integrated assessment models, the central one of which is the Dynamic Integrated Climate and Economy Model, for which William D. Nordhaus won the Nobel Prize in Economics in 2018.[51] Under DICE, global gross domestic product (GDP) in 2100 varies by about 3 percent across policy scenarios, including no climate policies at all, a figure that is both very small and almost certainly not statistically significant given the vagaries of economic forecasting and the number of years remaining before the end of this century. (I exclude here Nordhaus' "Stern discounting" policy scenario, as it assumes a discount rate effectively equal to zero, a fundamental analytic error.[52]) Per capita consumption varies only by about 1.3 percent

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[48] See https://crsreports.congress.gov/product/pdf/R/R46738.

[49] See https://www.federalregister.gov/documents/2009/12/15/E9-29537/endangerment-and-cause-or-contribute-findings-for-greenhouse-gases-under-section-202a-of-the-clean.

[50] See *Massachusetts* v. *EPA*, 549 U.S. 497, 525 (2007).

[51] See William Nordhaus and Paul Sztorc, "DICE 2013R: Introduction and User's Manual," Yale University, Department of Economics, October 2013, Figure 4 and Table 1, http://www.econ.yale.edu/~nordhaus/homepage/homepage/documents/DICE_Manual_100413r1.pdf. See also Benjamin Zycher, "The Climate Left Attacks Nobel Laureate Willian D. Nordhaus," monograph, American Enterprise Institute, July 2020, at https://www.aei.org/wp-content/uploads/2020/07/The-Climate-Left-Attacks-Nobel-Laureate-William-D.-Nordhaus.pdf.

[52] See, e.g., David Kreutzer, "Discounting Climate Costs," Heritage Foundation, June 16, 2016, at https://www.heritage.org/environment/report/discounting-climate-costs. See Nicholas Stern, *The Economics of Climate Change: The Stern Review* (Cambridge, UK: Cambridge University Press, January 2007),

across policy scenarios, also a very small number and almost certain not to be statistically significant.

The IPCC — even in its most alarmist analyses — arrives at a conclusion very close to that reported in the DICE analysis. In a recent report, it finds that the damage from anthropogenic climate change unmitigated by policy initiatives will reduce global GDP by 2.6 percent by 2100.[53] By that year, IPCC projects that individual incomes on average will be at least 400 percent greater than is the case today.[54]

A mandate from the Fed that large banks evaluate climate "risks" is likely to distort the allocation of capital away from economic sectors disfavored by certain political interest groups pursuing ideological agendas. This would represent the return of Operation Choke Point, an attempt to politicize access to credit, one far broader than was applicable only to financial institutions, and deeply corrosive of our legal and constitutional institutions. Protection of those institutions is consistent only with formal policymaking by the Congress through enactment of legislation, rather than with pressures exerted by the Fed and other regulatory agencies.

https://www.cambridge.org/us/academic/subjects/earth-and-environmental-science/climatology-and-climate-change/economics-climate-change-stern-review?format=PB.

[53] See Marco Bindi, *et. al.*, "Impacts of 1.5°C of Global Warming on Natural and Human Systems," at https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Chapter3_Low_Res.pdf, Chapter 3 of Valerie Masson-Delmotte, *et. al.*, eds., IPCC Special Report, *Global Warming of 1.5°C*, at https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf.

[54] This implies average annual growth in per capita GDP of less than 1.5 percent for the rest of this century.